NASA TT F-10,855

SPACE METEOROLOGY
(A Story About the Artificial Earth Satellite "Cosmos-144")

G. Golyshev, Deputy Chief of the Hydrometeorological Service of the USSR and I. Andronov

Translation of "Kosmicheskaya Meteorologiya"
Izvestiya, No. 64, page 5, 17 March 1967

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
WASHINGTON MARCH 1967

SPACE METEOROLOGY
(A Story About the Artificial Earth Satellite "Cosmos-144")

G. Golyshev, Deputy Chief of the Hydrometeorological Service of the USSR and I. Andronov

Five years ago, in accordance with the program announced by TASS on 16 March 1962, the first artificial earth satellite of the "Cosmos" series was placed in orbit in our country. Since that time, satellites of this series have been launched regularly. Their number is already approaching 150. "Cosmos" satellites have made an important contribution to the study of outer space, helped discover the picture of a number of physical processes which occur in the sun, and provided new and important information of distant objects of the universe.

But, in addition to great scientific significance, their launchings are beginning to acquire a vital national economic value. Today we publish a story about one of the satellites of the series -- "Cosmos-144", which was intended for the collection of meteorological information and its transmission to earth.

Flying around our planet now is the second weather satellite, "Cosmos-144", which was launched on 28 February in a near-polar orbit at an altitude of 625 kilometers. Installed in it, just as on board its predecessor "Cosmos-122", is scientific equipment which permits the weather service to obtain very important data on the state of the atmosphere above a vast territory of the planet. The launching of the satellite "Cosmos-144" continues work in the field of space meteorology which is being performed by our country in accordance with international agreement.

The alluring prospects for the use of artificial earth satellites are being confirmed convincingly in practice. Information on the state of the atmospheric processes, which is transmitted from space orbits, is used for weather forecasts

and for storm and typhoon warnings. Especially great is the value of meteorological information collected from vast territories of oceans, polar regions, and desert and mountain areas.

The preceding weather satellite "Cosmos-122" was in service continuously for four months and regularly provided extensive meteorological information. Television, infrared, and actinometric equipment as well as on-board control systems and systems for assuring the assigned operating regime of the satellite functioned in space for several thousand hours. Analysis of the operation of the satellite confirmed the correctness of the calculations and technical decisions which were made in the process of working it out and its creation. Accumulated during the satellite's operation was experience in the operational processing and use of information obtained from orbit in the weather forecasting service. The use of modern electronic computers to process the stream of information which arrives from space permitted the Hydrometeorological Center, USSR, of the Main Administration for Hydrometeorologi-Service, USSR, to transmit the results of the measurements to the weather services of a number of countries.

Experience has shown that the decision made in our country concerning the creation of a weather satellite which assures the simultaneous measurement of a number of indicators of the state of the atmosphere was correct and most effective. Execution of this task required from the creators of the satellite and the ground systems the solution of new problems of space technology which flow from the requirements for prolonged operation of the systems and measurement equipment in orbit in an exactly assigned regime and automation of the processing and dissemination of the meteorological information which is obtained.

A general view of the satellite "Cosmos-144" is shown in Figure 1. Two solar battery panels consisting of many thousands of photocells provide it with electric power. The basic service systems are located in the upper compartment of the container, and the scientific equipment of the satellite is located in the lower compartment. The "wings" of the solar batteries open after separation of the satellite from the carrier rocket. They are equipped with an autonomous tracking system which assures orientation of the plane of the battery perpendicular to the direction of the sun's rays in such a way that the maximum generation of electric power is assured. To protect against overcharging of the storage batteries or an intolerable lowering of the voltage, on board there is an automatic system for regulating the power supply of the satellite.

For the majority of the satellite's on-board instruments, electric power is required in the form of alternating current in a broad range of frequencies -- from tens to hundreds of cycles per second. The direct current of the storage battery is converted to alternate current by static semiconductor converters which, at the same time, are automatic voltage regulators and alternating current frequency regulators and assure the synchronous operation of the electric motors which are installed in various mechanisms on board the satellite.

During flight, the satellite is exactly oriented on the earth. One of its axes is directed to the center of the earth, a second along the trajectory, and a third perpendicular to the plane of orbit. The successful solution of the problem of the satellite's precise spatial orientation for prolonged continuous operation with the use of electric motor flywheels is a remarkable achievement of Soviet space technology. The exact orientation of the satellite permitted using so-called scanning infrared and actinometric equipment which, from orbit, follows processes in the earth's atmosphere, scanning it all the time in a transverse plane from right to left and left to right. And a strip of coverage is obtained due to the satellite's movement in orbit. Moreover, such orientation significantly facilitated processing the results of measurements. The satellite's onboard equipment includes, in addition to the orientation and power-supply systems, a number of electromechanical and radio electronic devices. They assure storage of the measurement results and their transmission to earth; the assigned temperature regime; a common time for tying the results of measurements to the terrain; and control and adjustment of the equipment's operating regime. Control of the complex group of the satellite's equipment is accomplished using an on-board automatic device as well as by commands from earth.

The equipment of satellite "Cosmos-144" permits obtaining a representation of the cloud condition, snow cover, and ice fields on the illuminated and dark sides of the earth and measuring the radiation fluxes which are reflected and emitted by the "earth-atmosphere" system. Television equipment is used to observe cloud cover on the illuminated side of the earth. Two cameras perform frame-by-frame /pokadrovoy/ photography of the earth's surface along the satellite's flight trajectory. The television equipment is turned on automatically with the sun's angle of elevation above the horizon of more than 5 degrees.

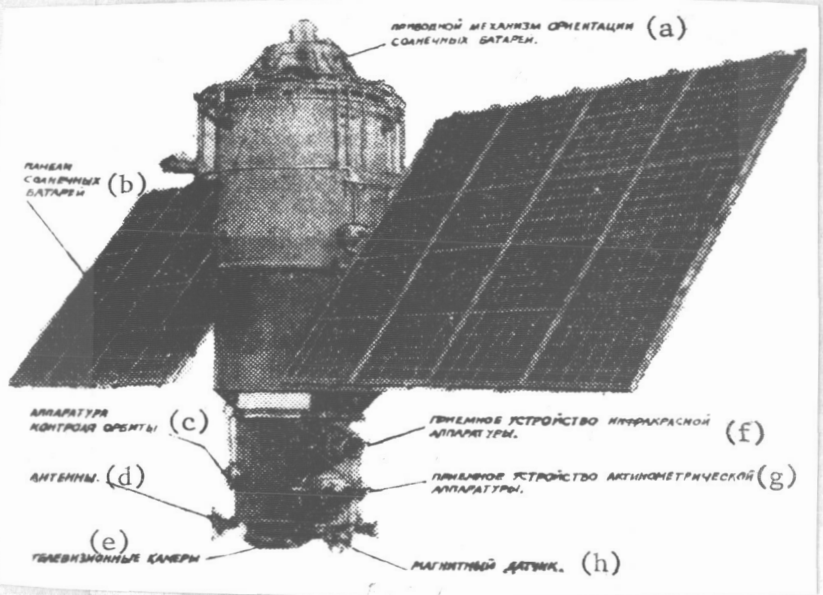

Fig. 1
a - drive mechanism for orienting the solar batteries; b - solar battery panels; c - device for controlling orbit; d - antennas; e - television camera; f - receiver for infrared equipment; g - receiver for actinometric equipment; h - magnetic data unit.

During the process of the satellite's flight, the earth's illumination changes considerably due to the changes in the character of the underlying surface as well as due to sun's altitude. In order to obtain high-quality photos, exposure is regulated using an automatic device which measures the illumination of the earth and which sets the required stop of the optical equipment. From an altitude of about 625 kilometers, the television cameras provide photography of the earth's surface along the satellite's flight trajectory with a width of take of about a thousand kilometers. The high resolution of the photography permits the sharp determination of the shape of the cloud cover and the performance of a detailed analysis of the atmospheric processes which occur in the given region.

For the sake of illustration, we present a photograph obtained from the satellite on 2 March at 1601 hours on the 29th orbit of its flight. The satellite's trajectory proceeded across the Indian Ocean from south to north. In the photo,one can clearly see the east coast of Africa north of the island of Zanzibar. Cloudless weather along the coast extends for more than a thousand kilometers. At a distance of about 100

kilometers from the outline of the coast there are cumulus clouds and light clouds of good weather over a tremendous territory which arise due to ascending currents. To the northwest of the island of Zanzibar, a considerable area is covered with clouds. In the upper right-hand corner, one can clearly see three tremendous centers of thick cumulus cloudiness. These rain clouds with storm rainfalls and thunderstorms are considerable, and the radius of one of them is about 50 kilometers.

Observation of the cloud cover on the dark side of the earth is accomplished using infrared equipment which measures the outgoing radiation of the earth's surface and clouds, the amount of which depends on their temperature. The infrared sector of the spectrum is selected for measurement on the basis that in this waveband radiation of thermal energy by the earth's surface and clouds is maximum and absorption of radiation by the earth's atmosphere is minimum. The amount of outgoing thermal energy is determined by the temperature of the radiating surface and, since the clouds are always cooler than the earth's surface, their radiation is less intense.

Continuous measurement of the amounts of thermal radiation of the surface "inspected" by the satellite permits obtaining data on the cloud cover not only on the dark side, but also on the illuminated side of the earth.

As a rule, the infrared equipment is turned on on complete orbits by the satellite around the earth. The receiver of the infrared device which is installed on board the satellite accomplishes a scanning movement perpendicular to the satellite's plane of flight, and this permits obtaining a width of strip of scan of about 1100 kilometers. Thermal radiation of the underlying surface and the clouds is converted by the equipment into electrical signals which are proportional to the amount of flux radiated. They are recorded by a memory device and transmitted to earth at a given moment.

Photos of cloud systems which are obtained using infrared equipment are less detailed than television photos but are sufficiently detailed for the analysis of large-scale atmospheris formations (cyclones, typhoons, atmospheric fronts) with characteristic cloud systems, the dimensions of which are measured in hundreds and more than a thousand kilometers. Information about cloud cover in the polar regions, especially in the Southern hemisphere, which is obtained using infrared equipment is at the present time the sole source of information which permits providing the necessary information about the nature of the weather in these regions.

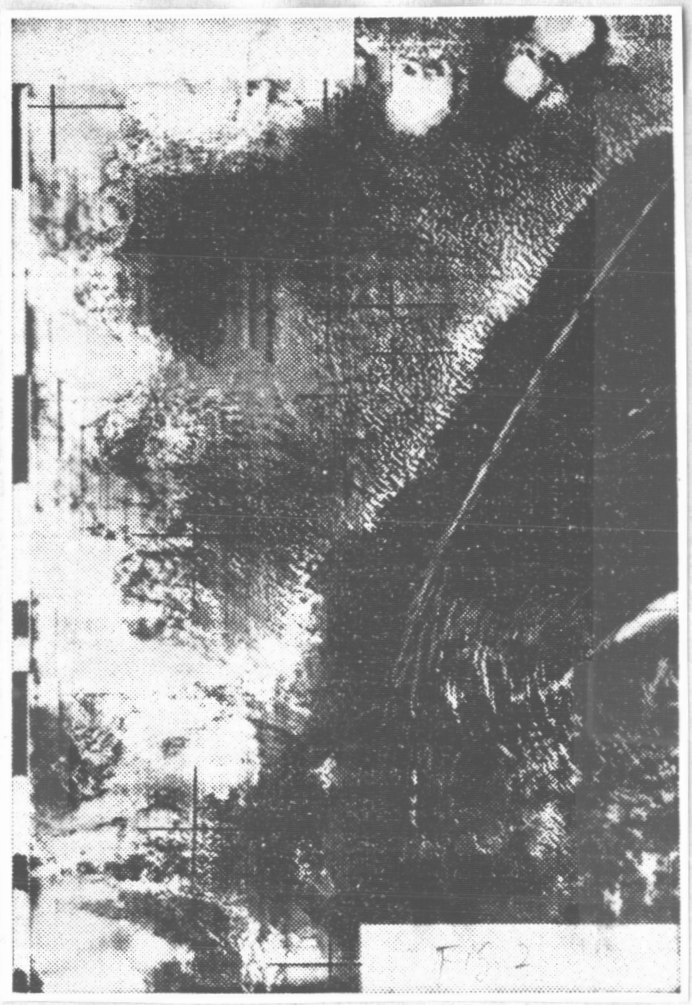

Fig. 2
The eastern coast of Africa north of the island of Zanzibar. Easily observed is the shore line where clear weather is observed. Visible at a distance of 100-150 km from the coast is the boundary of cumulus clouds and, further, cumulonimbus and cumulus clouds above africa.

In addition to scanning instruments, operating on board the satellite are two wide-angle cameras which encompass the entire disk of the earth visible from the satellite.

The complex of the system which provides meteorological measurements from the satellite includes reception points, processing points, and points for the transmission of data to institutions of the Hydrometeorological Service, USSR, and of other countries. Naturally, each type of measurments has its

own methods for processing, but a general thing is the unusual "abundance" of information and altogether 96 minutes which are provided in order to process it. When the satellite completes its patrol orbit, information obtained during the preceding oribt should already be processed.

Photographs which are made by television cameras should be corrected for false perspective of the optics which are obtained in photographing a broad strip of the earth's surface. Further, it is necessary to tie the image to geographic terrain and plot a coordinate grid. Almost all this difficult complex of work is performed using special electronic devices.

Using special equipment, the infrared image of the cloud cover is converted to a large-scale chart of the cloud cover. As a result of study of the photographs, nephanalysis charts (analysis of cloud cover) are compiled which are transmitted over lines of communication to the meteorological centers, to air weather stations at airfields, and to the hydrometeorological bureau.

The processing of the tremendous flow of results of actinometric measurements (measurement of thermal radiation) is performed using special electronic computers.

The creation ofthe artificial earth weather satellite and the complex of ground equipment, control, reception, and processing of information is to the great credit of the collectives of a number of institutes, design bureaus, and industrial enterprises of our country. It is a creative contribution of a large army of specialists in the annals of the glorious deeds of the anniversary year of the fiftieth anniversary of our Motherland.